TECHNICAL AND PROGRAMMATIC EVALUATION OF WIPP

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ABSTRACT

The Waste Isolation Pilot Plant (WIPP) has been constructed to be a repository for transuranic radioactive wastes generated from the U.S. defense activities. The U.S. Department of Energy had planned to start shipping waste to WIPP in October, 1988, but the physical plant was not ready, the shipping container was not certified, a number of regulatory requirements were not completed, and the justification for temporary emplacement of waste had not been developed. DOE is now moving swiftly towards completing a number of these requirements. A critical factor, however, remains the lack of demonstrable progress towards showing compliance with the Standards (40CFR Part 191) for long-term integrity of the facility. Without such compliance, the facility cannot be used for the purpose for which it has been built, that is, to permanently dispose of the defense transuranic radioactive waste.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is an underground geologic repository for the disposal of transuranic (TRU) wastes resulting from defense activities of the U.S. Government. The 50 hectare repository is located in southeastern New Mexico, 40 km east of Carlsbad, New Mexico, at a depth of 855 meters in the lower part of the 600-meter thick salt formation. The repository has been designed to dispose of approximately 178,000 cubic meters of contact-handled transuranic (CH-TRU) waste and 4,800 cubic meters of remote-handled transuranic (RH-TRU) waste for a total radioactive inventory of 14 million curies, (9 million curies CH-TRU and 5 million curies RH-TRU). The Public Law (P.L. 96-164, 1979) authorizing WIPP exempted it from licensing by the Nuclear Regulatory Commission (NRC). The State of New Mexico established a scientific evaluation group in 1978 to provide an independent technical evaluation of the WIPP Project. This Environmental Evaluation Group (EEG) has provided the only full-time interdisciplinary technical review and oversight of the WIPP Project since 1978. The effort has been totally funded by the U.S. Department of Energy (DOE). EEG also conducts an environmental monitoring program for background radioactivity in air, water and soil, both on-site and in surrounding communities. Both DOE and EEG have monitoring stations in the exhaust air discharge which will document the presence (or absence) of a release of radioactivity. EEG's evaluation has resulted in several recommendations for changes in the plans and for additional studies to resolve questions of the long and short-term safety of the project.

The U.S. Department of Energy (DOE), responsible for nuclear weapons production and disposal of radioactive waste resulting from such production, had planned to start shipping the waste to WIPP in October, 1988 (1). As the deadline approached, it became clear that DOE had not completed all of the preparations necessary to start this activity. The physical facility was not completed one out of four shafts had not been drilled and outfitted, the underground ventilation system was not completed, the equipment for continuously monitoring the air for radioactive releases underground had not been installed and tested, and the safety and emergency services building had not been completed. The Final Safety Analysis Report had not been completed. Testing of the transportation container (TRUPACT) for the CH-TRU waste had not been completed and the application for its certification had not been submitted to the U.S. Nuclear Regulatory Commission (NRC). And, perhaps most importantly, DOE had not prepared a justification for shipping the waste to WIPP. While DOE has always maintained that WIPP is a facility for performing research and development with radioactive waste for the first five years, plans for experiments requiring waste had not been developed when the deadline of October, 1988 arrived and passed.

This paper evaluates the technical and programmatic status of the WIPP Project as of February 1989 and reviews the work that is yet to be done before waste may be brought to the WIPP site in New Mexico.

TRU WASTE PRODUCTION AND INVENTORY

The production of defense transuranic (TRU) waste started in the 1940s with the initiation of nuclear weapons production, research, development, and testing in the U.S.A. TRU waste consists of discarded material that is contaminated with man-made radioactive elements with atomic numbers greater than uranium, such as plutonium, americium, curium, etc. It results from almost every industrial process involving transuranic materials, but predominantly from the fabrication of plutonium for nuclear weapons. The waste is soluble, respirable (up to 1% by weight can be less than 10 microns in particle size), and exists in a wide variety of physical forms, ranging from unprocessed general trash (absorbent papers, protective clothing, plastics, rubber, wood, and ion-exchange resins) to decommissioned tools and glove boxes (2). Major producers of WIPP-bound waste are the Rocky Flats Plant near Denver, Colorado; the Savannah River Plant near Aiken, South Carolina; the Hanford Complex of Facilities near Richland, Washington; and the Los Alamos National Laboratory in northern New Mexico. Smaller producers include the Mound Facility near Miamisburg, Ohio; the Argonne National Laboratory near Chicago; the Oak Ridge National Laboratory in Tennessee; and the Lawrence Livermore National Laboratory in Livermore, California. Over 70% of the radioactive content of RH-TRU is slated to come from the Oak Ridge National Laboratory.

Until 1970, the TRU category for radioactive waste did not exist and such waste was stored or buried at the

production sites in open, unlined trenches and then covered with several meters of earth. At the time of its burial, this waste was not intended to be retrieved, nor has any decision been made at this time to exhume the 150,000 m3 of buried waste. In 1970, the Atomic Energy Commission adopted a policy requiring that waste containing TRU nuclides producing more than 10 nanocuries of alpha activity per gram be packaged and stored separately from other radioactive waste (2). This limit was raised by DOE to 100 nanocuries per gram following a DOE workshop on TRU waste in Gaithersburg, Maryland in August 1982. Soon thereafter, the Nuclear Regulatory Commission (NRC) adopted a regulation (10CFR61 Part 55) using 100 nanocuries per gram as the concentration above which TRU waste would not generally be acceptable for near-surface disposal.

Because of limited space for storing the waste at Rocky Flats Plant (RFP), Argonne National Laboratory and the Mound Facility, the wastes produced at these laboratories has been shipped to Idaho National Engineering Laboratory (INEL) in Idaho Falls, Idaho since 1970. When DOE redefined TRU waste in 1982, the waste from these laboratories with less than 100 nanocuries per gram of alpha activity was shipped to the Nevada Test Site for shallow burial. LANL, Hanford, SRP, and ORNL have been storing the wastes produced by their facilities at the site. Some Plutonium-238 contaminated TRU waste from LANL and Mound was shipped to SRP in the 1970s and is stored there.

About 57,000 m3 of TRU waste is already stored at INEL for shipment to WIPP. This constitutes 32% of the 178,000 m3 CH-TRU design capacity of WIPP. Once the WIPP repository opens, DOE would prefer to ship the RFP waste from Colorado directly to WIPP instead of first shipping it to INEL. RFP produces about 1.6% of WIPP capacity waste annually which may be reduced by half (0.8%) when the new compactor at RFP becomes operational. The latest estimates of TRU waste inventories are provided by DOE in the Integrated Data Base Document (3).

The U.S. General Accounting Office (GAO) 1986 report (4) concluded that the DOE's Defense Waste Management Plan "does not fully explain DOE's position concerning the permanent disposal of pre-1970 buried waste and is silent concerning contaminated soil, which together represent 81 percent of DOE's TRU waste inventory".

HISTORY OF THE PROJECT

The Delaware Basin in southeastern New Mexico was selected for WIPP by the U.S. Geological Survey (USGS) and the Oak Ridge National Laboratory (ORNL), contractors to the U.S. Atomic Energy Commission (AEC), following the abandonment of the Lyons, Kansas site in 1972. Geologic characterizations started in 1974. In 1975, the responsibility for the WIPP site selection and characterization was passed on to the Sandia National Laboratories (SNL) in Albuquerque, New Mexico. In 1978, the State of New Mexico and DOE agreed to create a group of scientists and engineers (EEG) for the specific purpose of providing an independent technical review of WIPP. The WIPP Act (P.L. 96-164), passed in December 1979, provided for WIPP to be a facility for research and development exempted from regulation by the NRC. It also directed DOE to "consult and cooperate" with the State of New Mexico.

There were several changes in the mission of WIPP during the late 1970s and early 1980s. Both defense and commercial high level waste (HLW) were included and excluded several times. The Act directed DOE to complete a Consultation and Cooperation (C and C) Agreement with the State by September 1980, but the progress on these negotiations was slow. DOE issued the Final Environmental Impact Statement (FEIS) for WIPP in October, 1980. EEG had several substantial comments on this document that were not fully addressed by DOE. In January, 1981, DOE issued its Record of Decision to start construction in June 1981 and DOE's WIPP Project Manager declared that DOE needed nothing further from the State. The State's Attorney General filed a lawsuit against DOE in 1981 that immediately resulted in serious negotiations between the State and DOE resulting in a "Stipulated Agreement" and a "C and C Agreement" in July 1981. DOE agreed to address EEG's concerns about additional site characterization before starting construction. After reviewing the additional studies performed by DOE, EEG concluded in 1983 that the WIPP site appeared suitable for starting construction but some additional work on site characterization needed to be performed (5). DOE began construction at the site in Summer 1983. A modification to the C and C Agreement was signed in 1984 for the additional geotechnical work proposed by EEG in 1983. Most of these studies were completed in 1988 but several reports are yet to be issued.

The Environmental Protection Agency (EPA) "Standards for the Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Radioactive Wastes" (40CFR Part 191) apply to WIPP and the DOE is committed to meeting these Standards before permanently disposing TRU waste in the repository. The Standards were promulgated in September, 1985, but DOE has not yet (Feburary 1989) published even a single report to document the progress of work towards demonstrating WIPP's compliance with these Standards.

As early as 1983, DOE announced plans to start shipping TRU waste to WIPP for "Research and Development" in October 1988. The facility was not ready to receive the waste when that deadline approached. A number of hurdles have yet to be resolved.

SITE SUITABILITY

The characteristics of the WIPP site and the history of site characterization at WIPP are discussed in Chaturvedi and Rehfeldt, 1984 (6); Chaturvedi, 1986 (7); Chaturvedi et al., 1987 (8); and Chaturvedi, Channell, and Chapman, 1988 (9). Only a brief discussion of the issues yet to be resolved is provided here.

The WIPP repository is located in southeastern New Mexico, 40 km east of Carlsbad, New Mexico, at a depth of 855 meters in the lower part of a 600 meter thick Permian

age (225 million years old) salt formation known as the Salado Formation. The Salado extends from a depth of 260 meters to a depth of 860 meters at the WIPP site. Overlying the Salado Formation is a 95 meter (at the WIPP site) thick Rustler Formation that consists of anhydrite and siltstone with two water-bearing, fractured, dolomite beds. The lower one of the two, called the Culebra Member, contains more water and higher permeability. It is 8 meters thick at the repository and is located from 218 meters to 225 meters below the surface (430 to 438 meters above the repository). The upper one of the two Rustler water-bearing, dolomite beds is known as the Magenta Member and is located between 185 meters and 193 meters below the surface (10). Much of the WIPP site characterization effort has been spent on the hydrologic characterization of the Rustler water-bearing zones because these are expected to provide potential pathways for radionuclide migration to the biosphere in case of a breach of the WIPP repository.

Hydrologic characterization of the Rustler water-bearing zones is essentially complete and the magnitude and direction of flow of water through the Culebra is fairly well understood (11). Some issues concerning the Culebra remain controversial and unresolved. These relate to the amount of modern recharge to the Formation (12, 13), the timing of dissolution of the Rustler salt (14, 15, 16, 17, 18), and the geochemical evolution of the Culebra waters (13, 19).

An important geologic feature of the WIPP site is the presence of pressurized "brine reservoirs" in the upper part of the Castile Formation that have been encountered in several boreholes surrounding the WIPP site. The first exploratory borehole for WIPP (ERDA-6), drilled 7 km northeast of the center of the present site in 1975, encountered pressurized artesian brine and resulted in abandoning of that site. Another borehole (WIPP-12) located 1.6 km north of the center of the present site was drilled to a depth of 850 meters to the top of the Castile Formation in 1978. Accepting EEG's suggestions to explore the anticlinal structure indicated by seismic surveys at this location, DOE deepened this borehole in November, 1981. The hole encountered a pressurized brine reservoir at a depth of 920 meters. The initial flow rate of brine, under artesian pressure, was 1,600 liters per minute and after exhaustive testing, DOE estimated that the brine reservoir penetrated by WIPP-12 contains 2.7 billion liters (17 million barrels) of brine. Since DOE had planned to construct the repository in the northern part of the site that would have brought it within 140 meters of WIPP-12, DOE accepted EEG's suggestion to relocate the repository to its present location, 2 km south of the previous location.

At EEG's insistence, DOE had electromagnetic geophysical surveys performed over the WIPP repository area. The results (20) show a clear indication of the presence of brine under parts of the WIPP repository. Based on the encounter of brine in 13 out of 60 boreholes in the vicinity of the WIPP site, one of which (Belco-Hudson) is only 5 km southwest of the repository (6), the encounter at WIPP-12 and the geophysical survey results, it is necessary to assume that pressurized brine exists at a depth of approximately 250 meters below the repository.

The question of the amount of brine expected to seep from the repository salt into the excavations is another important parameter that needs to be understood for reliable predictions of future behavior of the repository and potential breaches. It appears that the Salado salt may be saturated with brine and the brine inflow from it, albeit at low permeability and low porosity, may fill the repository with brine once the ventilation of the facility ceases to remove moisture (21). The effects of this on a human intrusion scenario could be unacceptable (9). DOE has therefore planned to perform a series of in situ tests to determine the permeability and porosity of the salt beds of the WIPP repository and to actually measure the amount of brine inflow.

DESIGN SUITABILITY

The WIPP repository consists of eight "panels" with seven "rooms" in each panel. Each room is designed to be 300 feet (91.5 meters) long, 33 feet (10 meters) wide, and 13 feet (4 meters) high. CH-TRU waste will be emplaced in 55-gallon drums stacked three high in the rooms and in the drifts connecting the rooms. Odd-sized and shaped waste will be emplaced in specially designed boxes. RH-TRU waste will be disposed in 36 inch (0.91 meter) diameter horizontal holes in the walls of most of the rooms.

The first set of experimental rooms at WIPP were excavated and have been monitored since 1983. The closure rate of the rooms due to salt creep has been found to be 3.5 times the predicted rate and this led to some changes in the design (9). In spite of laboratory and in situ research for a number of years (22), DOE has yet to make a decision on the type of backfill material to be used in the repository rooms. The design and materials for the shaft and panel seals and for plugging the boreholes within the site are also at an experimental stage (22).

PERFORMANCE ASSESSMENT

"Performance Assessment" refers to the assessment of compliance of a nuclear waste repository with the EPA "Standards for the Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Radioactive Wastes" contained in 40CFR Part 191. WIPP is required to meet these standards as will the High Level Waste (HLW) repository for commercial and defense HLW.

The EPA Standard contains two subparts. Subpart A specifies maximum allowable releases for management and storage of radioactive waste and applies to facilities designed for temporary retention of the waste. Standards for disposal contained in Subpart B were developed to assure long-term integrity of a geologic repository for nuclear waste and would apply to the Nevada repository for high-level waste and to WIPP. Since the waste should be received, handled, examined and transported underground before permanent emplacement in a repository, Subpart A provisions also apply to a geologic repository for that phase of the work. Compliance with Subpart A is required for WIPP but the main standards for a geologic repository for

radioactive waste are contained in Subpart B. Subpart A simply requires that the waste handling activities should be designed and performed in such a manner so as to provide a reasonable assurance that any member of the public in the general environment should not receive a combined annual dose equivalent exceeding 25 millirems to the whole body and 75 millirems to any critical organ. The requirements for NRC licensed facilities are more stringent.

The EPA Standards (40CFR Part 191) are based on a probabilistic risk assessment and do not require any emplacement of waste for demonstrating compliance. The methodology for performance assessment of a geologic radioactive waste repository consists of the following: (i) procedures for scenario development; (ii) models for use in estimating consequences from these scenarios; and (iii) procedures for combining these estimates into an overall compliance assessment with regulatory standards (23). For a detailed discussion of the standards as they apply to WIPP, see Chaturvedi et al., 1987 (8).

DOE has claimed since the promulgation of the Standards in 1985 that they need to emplace some waste underground for temporary periods to obtain data that would be necessary for demonstrating compliance. The experiments needed for this purpose and the amount of waste required for these experiments have not been defined to date (February, 1989). In fact, no document showing progress in performance assessment of WIPP has yet been published by DOE, not even a list of scenarios to be examined. DOE has published a schedule (24) for performance assessment of WIPP and it shows that compliance with Subpart B of the Standards will not be completed until October, 1993.

Subpart B of the Standards was vacated by the First Circuit Court of Boston in June 1987 on grounds that they were less stringent than the Clean Water Act of 1971, and no explanation was provided by EPA for this discrepancy. The Standards were remanded to the EPA for revision and repromulgation. Shortly after this action, New Mexico entered into a modification to the C and C Agreement with DOE to evaluate WIPP against the vacated 1985 Standards because the technical requirements of the revised Standards are not expected to differ substantially. EPA expects to repromulgate the Standards in October, 1991.

OPERATIONAL READINESS

Early in 1988, the WIPP project personnel declared, "The WIPP facility is scheduled to be operationally ready to receive its first shipment of waste in October of 1988" (25). The prediction was optimistic and WIPP is not operationally ready to start receiving the waste. EEG has been intimately involved with several aspects of the operational readiness at WIPP. The following discussion includes the issues that have been satisfactorily resolved as well as the unresolved issues.

Exhaust Stack Monitoring

The initial design and construction of the discharge stack at WIPP created fluctuating and turbulent air flow conditions which were totally unsuited for sampling, as defined by DOE Orders and American National Standards Institute (ANSI) Standards. Compliance was sought through the use of untested and unproven flow conditioning technology which subsequently proved unacceptable when subjected to test and measurement (26). By virtue of extensive redesign and construction, a new stack and fan system has been installed and successfully tested. This issue has been resolved.

Design and Placement of Sample Probes and Sample Transport Lines

The original discharge stack design called for placement of sample probes in close proximity to sources of major disturbances in flow. The associated probe design compounded the problem by emphasizing multiple, small diameter, sample extraction nozzles and associated tubes. This design was inherently susceptible to failure due to plugging by salt dust, and would not be capable of extraction of particulates over a suitably wide range of aerodynamic diameters. The sample transport lines were equally poorly designed. This issue was resolved along the lines recommend by EEG (26) in three ways:

a. new large diameter probes were designed which were simpler in operation and exhibited far superior performance under both laboratory and field tests;
b. these new probes were positioned in stable air flow conditions;
c. these new probes were coupled with newly designed, vertically oriented, sample transport lines that were capable of delivering a suitable sample to the CAM heads.

Continuous Air Monitoring Instrument Design

The original CAM head design further degraded system performance. The aerosol inlet to the CAM head created a condition leading to substantial aerosol loss by impaction (27). Further, the L x-ray detection system was both inefficient and susceptible to interference by radon and thoron daughters. This issue has been addressed by a complete redesign of the aerosol inlet and filter holder assembly. The CAM head has passed thorough testing. A new detector and data processing and alarm system based on alpha detection has been installed and is being tested. It remains to be seen if this new design will be sensitive and yet not create an unacceptably large false alarm rate. The issue, therefore, is unresolved.

During the last 12 to 18 months, WIPP has brought health physics staffing near to the projected operational needs, written a Radiation Safety Manual, initiated general employee and radiation worker training courses, prepared most of the specific health physics procedures, and begun acceptance testing and calibration of radiation monitoring equipment.

Unique problems confronting the WIPP health physics personnel are: (a) developing appropriate methods for contamination control; (b) qualifying the salt-laden continuous air monitors; (c) detecting potential underground airborne contamination so that exhaust shaft air can be HEPA filtered; (d) restricting use of water as a decontaminating

agent; and (e) transitioning from a long-term construction site to a radiological facility.

Some common tasks the WIPP health physicists must complete are certification of the personnel dosimeter, documentation of whole body count baseline information, and operational testing and acceptance of written procedures.

EEG's future review will emphasize the training and qualifications of the health physics staff, suitability of radiation instrumentation, and appropriateness of the radiological design of the Waste Handling Building and underground complex.

TRANSPORTATION READINESS

Establishing an acceptable transportation system for 20,000 truck shipments of transuranic wastes to WIPP is predicated on:

1)reasonable confidence in the ability of the shipping container to confine the radioactive contents in the event of an accident;

2)designation of routes to be used and assurance that they will minimize traffic accidents;

3)training of emergency response workers to be able to cope with potential accidents.

This paper will not discuss the latter two efforts. Although the WIPP Environmental Impact Statement (2) included rail transportation as an option, there are no plans to transport waste by rail.

In 1980, EEG published (28) calculations of radiation doses resulting from the possible radioactive material released in hypothetical transportation accidents to WIPP. The doses were assumed to result from the inhalation of re-suspended radionuclides and the ingestion of contaminated food or water. Postulated releases from RH-TRU accidents clearly indicated the need to undertake protective action measures. The issue of the generation of hydrogen from radiolysis during waste shipments was raised by EEG in 1983 (29). To avoid the problem of pressurization of the container from gas generation, DOE planned to incorporate a venting feature in the shipping container which would violate NRC regulations for "Type B" containers. The inadequacy of the rectangular TRUPACT design to meet NRC regulations was the subject of a 1986 EEG report (30). In mid-1987, DOE contracted for a new right circular cylinder design requiring NRC licensing. Considerable progress has been made in the past 1 1/2 years in the design, construction, and testing of the container.

The first unit of the right circular cylinder design did not meet the NRC leakage requirements for both containment vessels. The design was modified and two additional units were constructed and tested. The second unit appeared to meet the leakage requirements, but leakage measurements on the third unit following the burn test did not indicate full compliance.

A fourth shipping container is scheduled to be fabricated and undergo a series of drop tests before measurements of the leakage integrity are made. If the tests are successful, DOE plans to submit the Safety Analysis Report for Packaging (SARP) to NRC for certification of TRUPACT-II, the shipping container to be used for transporting CH-TRU waste to WIPP. EEG will also review the SARP.

MIXED WASTE ISSUE

When EPA issued a "regulatory interpretation" of its 1976 Resource Conservation and Recovery Act (RCRA) in July 1986, a large percentage of the TRU waste bound for WIPP became "mixed waste". The "mixed wastes" are those that contain both radioactive waste and chemical hazardous waste, and, therefore, have to comply with RCRA regulations as well. Following EPA's publication of the "regulatory interpretation" of RCRA, DOE promulgated a new definition of by-product material in May, 1987 (10CFR Part 962) that brought WIPP bound waste under dual regulations of the Atomic Energy Act (AEA) and RCRA.

Between 70% and 80% of all waste to be shipped to WIPP is classified as "mixed waste". These wastes have to be in compliance with RCRA regulations. DOE is working with EPA and the State of New Mexico to obtain a "no-migration" exemption from the land disposal restrictions. The "no-migration petition" document is scheduled to be ready in March, 1989, and EPA has indicated that it would require between six months and two years to reach a decision on it. Another complication that may delay shipping the waste to WIPP is the lack of authority in the State of New Mexico to administer the mixed waste program. New Mexico did not seek this authority from EPA, and the State's 1978 Hazardous Waste Act was amended in 1987 to not apply to WIPP; "Nothing in the Hazardous Waste Act shall be construed to apply to any radioactive waste processed and certified for emplacement in the mined geologic repository at the Waste Isolation Pilot Plant" (Section 74-4-3-2 NMSA 1978, new section inserted in 1987). The 1989 legislature is expected to repeal this section and the State will have to apply for authorization to regulate the WIPP bound mixed waste.

CONCLUSIONS

The Waste Isolation Pilot Plant (WIPP) is a much needed repository for providing a permanent solution to large quantities of accumulated TRU radioactive waste from the nation's defense activities. In spite of 15 years of work at the site, the facility is not yet ready to start receiving waste. Much work has been accomplished and the facility and the shipping container should be ready for shipping, handling, and emplacement of waste in the future.

A major obstacle in using the facility as a repository is the lack of progress towards demonstrating that the repository would safely contain the waste for a long time in the future. EPA promulgated a set of standards for this purpose in 1985. Although these Standards were "vacated" by a court in 1987, the State of New Mexico and DOE agreed to evaluate the project according to the vacated Standards. DOE published a plan for compliance with these Standards in 1988 that outlined a number of reports to be published

with a final compliance report in 1993. For example, a report on scenarios scheduled for 1987 has not yet been published. No other discernible progress has been made towards demonstrating compliance with these standards. To justify emplacing the waste at WIPP before showing compliance with the Standards, DOE has stated that certain experiments need to be performed to provide data for calculating risks to show compliance with these Standards. These experiments have not yet been identified but are expected in the near future. The best course for DOE to pursue appears to be to provide a justification for temporary emplacement of waste at WIPP in addition to completing the "nuts and bolts" aspects of the operation before planning to ship a large quantity of waste to WIPP.

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